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General Corrosion Resistance Comparisons of Medium- and High-Strength Aluminum Alloys for DOD Systems Using Laboratory-Based Accelerated Corrosion Methods

by Brian E. Placzankis

ARL-TR-4937 September 2009

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14. ABSTRACT
Test specimens of various aluminum alloys common to U.S. Department of Defense (DOD) systems or proposed for use in DOD systems were identically prepared and exposed under bare uncoated conditions in chamber-based, laboratory-accelerated corrosion test methods to assess their relative susceptibilities to general corrosion attack. The methods used were ASTM B 117 neutral salt fog (NSF) and General Motors Standard 9540P (GM 9540P) cyclic accelerated corrosion. The NSF specimens were compared at intervals of 18, 72, and 168 h. The GM 9540P specimens were assessed at 1, 5, and 10 cycle intervals. The corrosion assessments were graphically obtained using flatbed scanning techniques.

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1. Introduction

Current U.S. Department of Defense (DOD) systems use a wide variety of aluminum alloys in their designs to meet their mission needs. Among the varieties used are the heat-treatable alloys such as the 2000, 6000, and 7000 series alloys and the strain hardened nonheat-treatable 5000 series alloys. All of these materials have their respective merits in areas such as mechanical performance, ballistic performance, weldability, corrosion resistance, availability, and price. Tables 1–5 list the alloying elements and mechanical properties for the alloys examined in this study (*1–12*). The mechanical properties listed for the armor U.S. Military Specification qualified armor alloys in tables 3 and 4 are minimum acceptance values. The actual mechanical properties for these alloys are significantly greater when delivered. The mechanical properties listed for the remaining alloys are based upon open established values in industry and manufacturer's specifications.

Table 1. Chemical composition requirements for military specification qualified aluminum armor alloys.

Element	**5059 (%)**	**5083 (%)**	**5456 (%)**	**6061 (%)**	**7039 (%)**	**2219 (%)**	**2519 (%)**
Silicon	0.50 max	0.40 max	0.25 max	0.40–0.8	0.30 max	0.20 max	0.25 max
Iron	0.50 max	0.40 max	0.40 max	0.7 max	0.40 max	0.30 max	0.30 max
Copper	0.40 max	0.10 max	0.10 max	0.15–0.40	0.10 max	5.8–6.8	5.3–6.4
Manganese	0.60–1.2	0.4–1.0	0.5–1.0	0.15 max	0.10–0.40	0.20–0.40	0.10–0.50
Magnesium	5.0–6.0	4.0–4.9	4.7–5.5	0.8–1.2	2.3–3.3	0.02 max	0.05–0.40
Chromium	0.30 max	0.05–0.25	0.05–0.20	0.04–0.35	0.15–0.25	—	—
Zinc	0.40–1.5	0.25 max	0.25 max	0.25 max	3.5–4.5	0.10 max	0.10 max
Titanium	0.20 max	0.15 max	0.20 max	0.15 max	0.10 max	0.02–0.10	0.02–0.10
Zirconium	0.05–0.25	—	—	—	—	0.10–0.25	0.10–0.25
Vanadium	—	—	—	—	—	0.05–0.15	0.05–0.15
Lithium	—	—	—	—	—	—	—
Silver	—	—	—	—	—	—	—
Others (each)	0.05 max	0.05 max	0.05 max	0.05 max	0.05 max	0.05 max	0.05 max
Others (max)	0.15 max	0.15 max	0.15 max	0.15 max	0.15 max	0.15 max	0.15 max
Aluminum	Remainder	Remainder	Remainder	Remainder	Remainder	Remainder	Remainder

Table 2. Chemical composition requirements for additional military aluminum alloys.

Element	2024 (%)	2139 (%)	2195 (%)	5086 (%)	5383 (%)	5454 (%)	6013 (%)	7022 (%)	7075 (%)
Silicon	0.50 max	0.1 max	0.12 max	0.40 max	0.25 max	0.40 max	0.6–1.0	0.50 max	0.40 max
Iron	0.50 max	—	0.15 max	0.50 max	0.25 max	0.40 max	0.50 max	0.50 max	0.50 max
Copper	3.8–4.9	4.0–5.5	3.7–4.3	0.10 max	0.20 max	0.10 max	0.60–1.1	0.50–1.0	1.2–2.0
Manganese	0.30–0.90	0.2–0.6	0.25 max	0.2–0.7	0.7–1.0	0.5–1.0	0.20–0.80	0.10–0.40	0.30–max
Magnesium	1.2–1.8	0.2–0.8	0.25–0.80	3.5–4.5	4.0–5.2	2.4–3.0	0.80–1.2	2.60–3.70	2.1–2.9
Chromium	0.10 max	—	—	0.05–0.25	0.25 max	0.05–0.20	0.10 max	0.10–0.30	0.18–0.28
Zinc	0.25 max	—	0.25 max	0.25 max	0.40 max	0.10 max	0.25 max	4.30–5.20	5.1–6.1
Titanium	0.15 max	—	0.10 max	—	0.15 max	0.20 max	0.10 max	0.20 max	0.20 max
Zirconium	—	—	0.08–0.16	—	0.20 max	—	—	0.20 max	—
Vanadium	—	—	—	—	—	—	—	—	—
Lithium	—	—	0.8–1.2	—	—	—	—	—	—
Silver	—	0.15–0.6	0.25–0.6	—	—	—	—	—	—
Others (each)	0.05 max	0.05 max	0.05 max	0.05 max	0.05 max	0.05 max	0.05 max	0.05 max	0.05 max
Others (max)	0.15 max	0.15 max	0.15 max	0.15 max	0.15 max	0.15 max	0.15 max	0.15 max	0.15 max
Aluminum	Remainder	Remainder	Remainder	Remainder	Remainder	Remainder	Remainder	Remainder	Remainder

Table 3. Minimum mechanical acceptance requirements for military specification aluminum armor alloys.

Property/Alloy	5083-H116	5083-H131	5083-H321	5456-H116	5456-H131	5456-H321
Yield stress (ksi)	31	35	31	33	35	31
Ultimate stress (ksi)	44	45	44	46	45	44
Elongation (%)	10	8	10	10	8	10
Density (g/cm^3)	2.66	2.66	2.66	2.66	2.66	2.66

Table 4. Minimum mechanical acceptance requirements for military specification aluminum armor alloys continued.

Property/Alloy	5059-H131	5059-H321	6061-T651	7039-T64	2219-T87	2519-T87
Yield stress (ksi)	44	44	35	51	46	58
Ultimate stress (ksi)	57	57	38	60	62	68
Elongation (%)	8	10	10	9	7	7
Density (g/cm^3)	2.66	2.66	2.70	2.74	2.84	2.82

Table 5. Mechanical properties for additional military aluminum alloys.

Property/Alloy	2024-T3	2139-T8	2195-BT	5086-H116	5383-H131	5454-H34	6013-T651	7022-T651	7075-T651
Yield stress (ksi)	50	67	67	30	32	35	52	54	73
Ultimate stress (ksi)	70	72	73	42	44	44	55	65	83
Elongation (%)	18	15	13	12	10	10	5	7	9
Density (g/cm^3)	2.78	2.80	2.71	2.66	2.66	2.69	2.71	2.77	2.81

Though corrosion resistance is certainly a desirable characteristic for any particular material, it is one attribute that is often overlooked or underestimated by designers of weapon systems or platforms. A variety of sources exists for referencing corrosion resistance and performance of aluminum alloys such as the ASM Metals Handbook (*13*), Corrosion Engineering by Fontana (*14*), and a myriad of individual papers and reports from a variety of institutions such as NACE (*15*), TMS (*16*), and JOM (*17*). What is currently lacking is a single convenient source for accelerated corrosion data for the aluminum alloys utilized by DOD for engineers and contractors to reference when making design decisions for new weapon systems or as upgrades to existing platforms. The goal of this report is to supply basic accelerated corrosion data from two of the most commonly used laboratory-based accelerated corrosion methods. It should never be interpreted as the complete story on predicting how any particular alloy will perform over time in any or all fielded environments but merely as a useful comparative piece of the overall design puzzle. Additional corrosion vulnerability data from other sources such as the U.S. Army Aberdeen Test Center Automotive Test Track, longer-term outdoor exposures, and prior corrosion data actual fielded platforms should play a dominant role in the final design decision-making process. This study represents a "snapshot" of the alloys currently in use or of interest. Gradually, as new and improved aluminum alloys are developed and introduced for defense applications, this reference will become less complete in time and need to be revised.

2. Experimental Procedure

The purpose of this study was to assess the inherent corrosion resistance capabilities of the bare unprotected aluminum alloys currently in use or proposed for use by DOD. A wide selection of aluminum alloys was chosen from both ground-, marine-, and aviation-based systems. The alloys of various tempers listed in numerical order include the following: AA2024-T3 (*6*), AA2139-T8 (*7*), AA2195-BT (Balanced Temper) (*8*), AA2219-T87 (*1*), AA2519-T87 (*2*), AA5059-H131 (*3*), AA5059-H321 (*3*), AA5083-H131 (*3*, *18*), AA5083-H321 (*3*, *18*), AA5086-H116 (*9*), AA5383-H116 (*8*), AA5454-H34 (*10*), AA5456-H116 (*3*, *19*), AA5456-H131 (*3*, *18*), AA6013-T651 (*8*), AA6061-T651 (*4*), AA7022-T651 (*11*), AA7039-T64 (*5*), and AA7075-T651 (*12*). Due to the wide range of applications and widespread use for ground and marine systems, heavy representation existed among the 5000 series alloys including multiple tempers among some of the different examples.

The actual aluminum specimens were cut to 1.75- × 1.5- × 0.25-in nominal dimensions using a water cooled Beuhler Abrasimet saw. They were then finished to a 600-grit surface via metallographic grinding techniques. The majority of the alloys studied originated from 0.25-in-thick plates. However, when the specimens were obtained from thicker rolled plates, they were down-sectioned to 0.25 in via the short transverse plane, with only the outward facing exterior surfaces used for the exposures. Following grinding, the specimens were cleaned and rinsed using acetone organized in racks (as noted in figure 1) and placed into their respective chambers.

Figure 1. Corrosion rack configuration used for neutral salt fog (NSF) and GM 9540P exposures.

A Harshaw Model 22 test chamber was used for NSF testing, and an Attotech Model CCT-NC-30 was used for cyclic testing. The NSF operating parameters were in accordance with ASTM B 117 (*20*) at 95 °F, with saturated humidity and an atomized fog of 5% NaCl solution. The observation and scanning intervals for the specimens in NSF were 18, 72, and 168 h. The GM 9540P (*21*) cyclic accelerated corrosion test consisted of 18 separate stages that included the following: saltwater spray using 0.9% NaCl, 0.1% $CaCl_2$, 0.25% $NaHCO_3$ test solution, high humidity, drying, ambient, and heated drying. The environmental conditions and duration of each stage for one complete cycle are provided in table 6.

Table 6. GM 9540P cyclic corrosion test details (*2*).

Interval	**Description**	**Time (min)**	**Temperature (±3 °C)**
1	Ramp to salt mist	15	25
2	Salt mist cycle	1	25
3	Dry cycle	15	30
4	Ramp to salt mist	70	25
5	Salt mist cycle	1	25
6	Dry cycle	15	30
7	Ramp to salt mist	70	25
8	Salt mist cycle	1	25
9	Dry cycle	15	30
10	Ramp to salt mist	70	25
11	Salt mist cycle	1	25
12	Dry cycle	15	30
13	Ramp to humidity	15	49
14	Humidity cycle	480	49
15	Ramp to dry	15	60
16	Dry cycle	480	60
17	Ramp to ambient	15	25
18	Ambient cycle	480	25

In addition, the cyclic chamber was calibrated with standard steel mass loss calibration coupons as described in the GM 9540P test specification. Although the GM 9540P procedure was developed for steel substrates, previous studies (22) have shown that the cyclic nature of the exposure and the electrolyte used can have a significant corrosion impact, particularly among the 2000 and 7000 series alloys. The observation and scanning intervals for the GM 9540P specimens were 1, 5, and 10 cycles. In order to visually assess and characterize the corrosion, all specimens were scanned at 1200 dpi optical resolution at their respective intervals using color flatbed scanning techniques.

3. Results

After just 18 h of NSF exposure, it was readily apparent that the 2000 and 7000 series containing the highest copper alloying additions exhibited the most corrosion, mainly from pitting attack, while the 5000 and 6000 series had less. The corrosion types and quantities observed for the various alloys followed expectations from series to series, with some interesting exceptions.

3.1 2000 Series Alloys

The 2000 series alloys are often utilized in DOD in aviation and armor applications for their high strength and excellent performance in ballistics. The alloy 2024-T3 has been used for decades in U.S. Navy and Air Force aircraft for its excellent mechanical properties. The alloys AA2519-T87 and 2219-T87 form the basis for the Military Specifications MIL-DTL-46192C (*2*) and MIL-DTL-46118E (*1*), respectively, for armor. The 2000 series most documented vulnerability is corrosion from pitting attack. As expected, the 2000 series alloys possessing high percentages of copper alloying exhibit the most severe corrosion. The scanned images in figures 2–11 show the relative corrosion severities sustained on the 2000 series alloys during the course of their exposures.

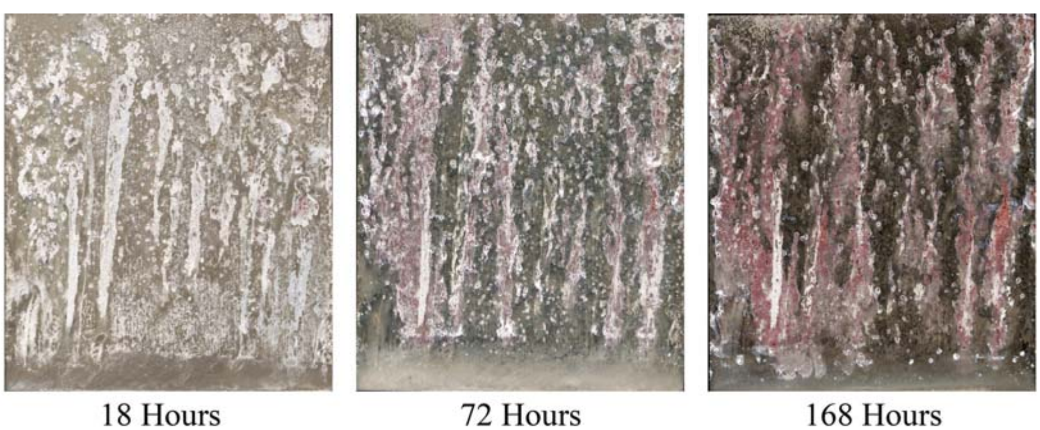


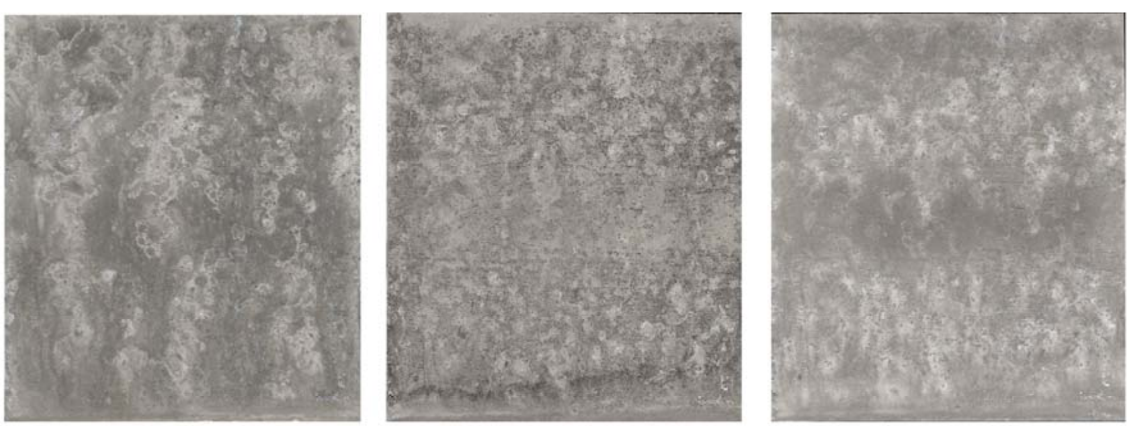
Figure 2. AA2024-T3 after NSF.

1 Cycle | 5 Cycles | 10 Cycles

Figure 3. AA2024-T3 after GM 9540P cyclic corrosion.

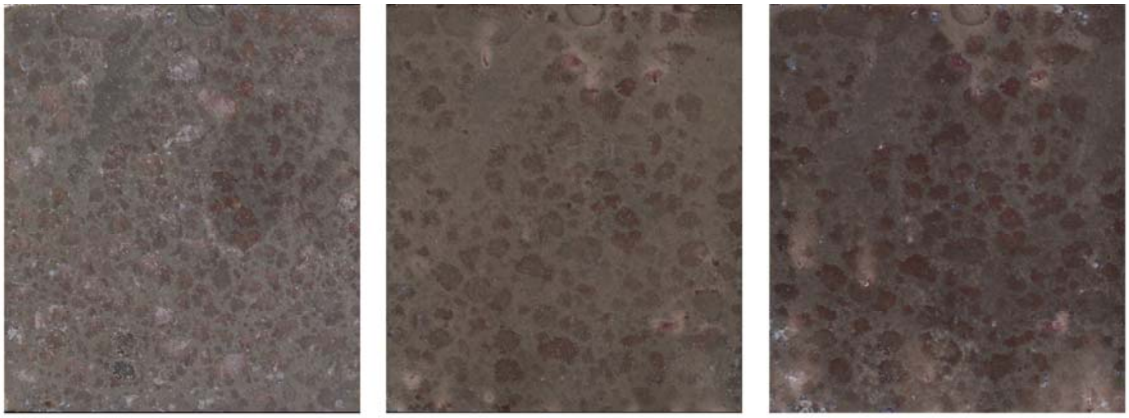
18 Hours | 72 Hours | 168 Hours

Figure 4. AA2139-T8 after NSF.



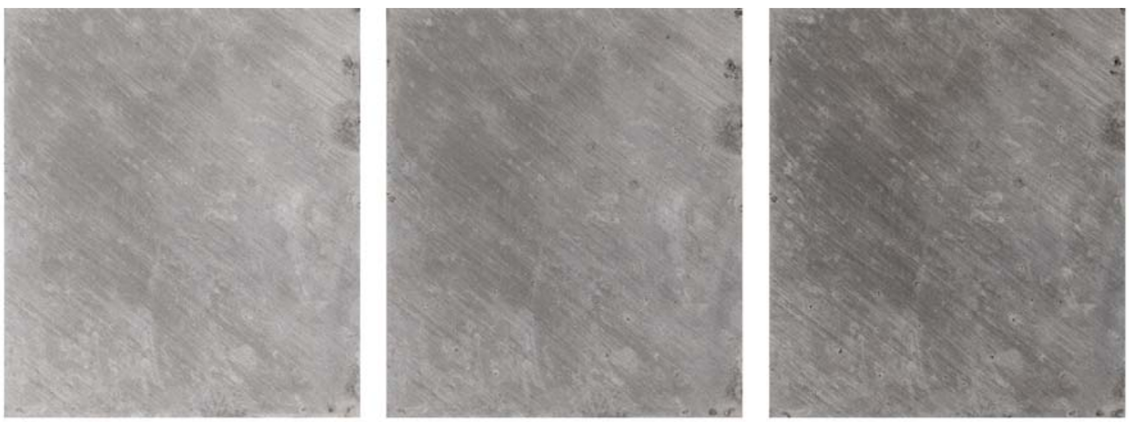
1 Cycle | 5 Cycles | 10 Cycles

Figure 5. AA2139-T8 after GM 9540P cyclic corrosion.



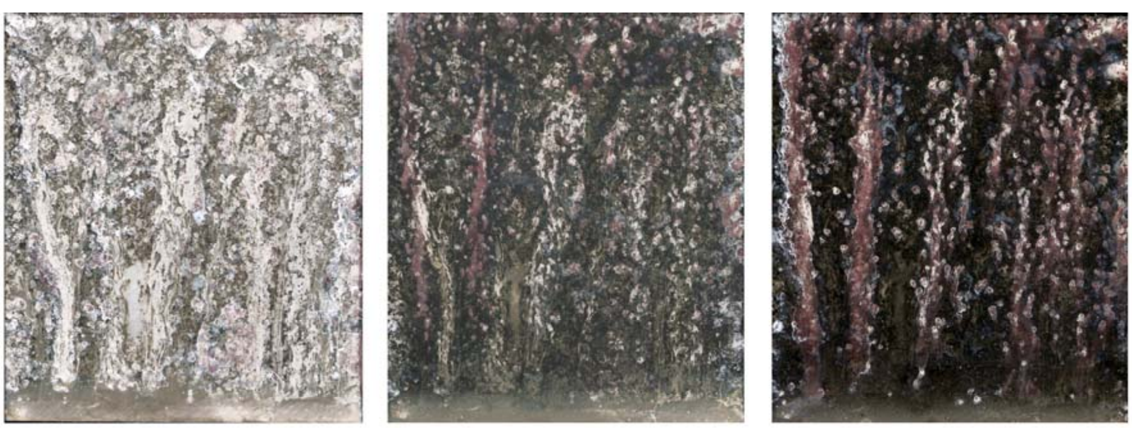
18 Hours | 72 Hours | 168 Hours

Figure 6. AA2195-BT after NSF.



1 Cycle | 5 Cycles | 10 Cycles

Figure 7. AA2195-BT after GM 9540P cyclic corrosion.



18 Hours | 72 Hours | 168 Hours

Figure 8. AA2219-T8 after NSF.

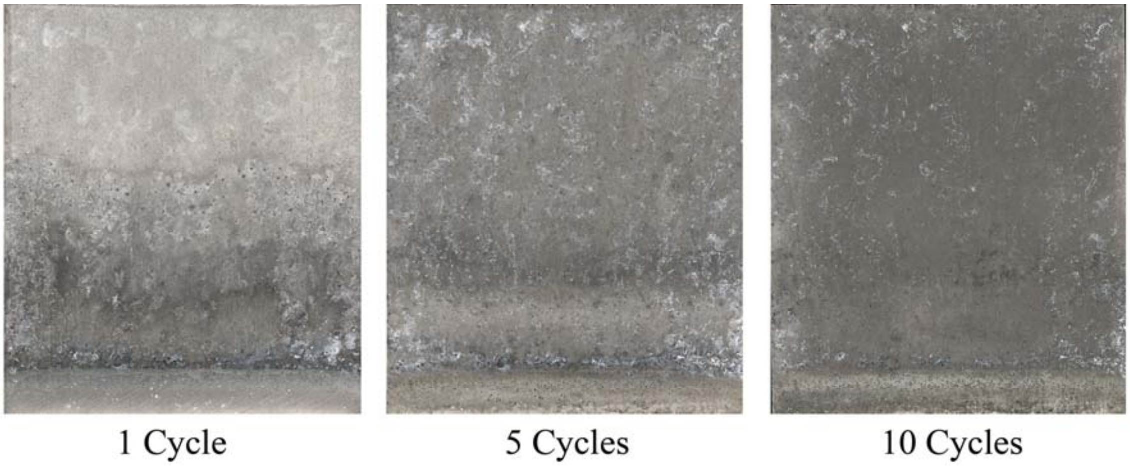


Figure 9. AA2219-T8 after GM 9540P cyclic corrosion.

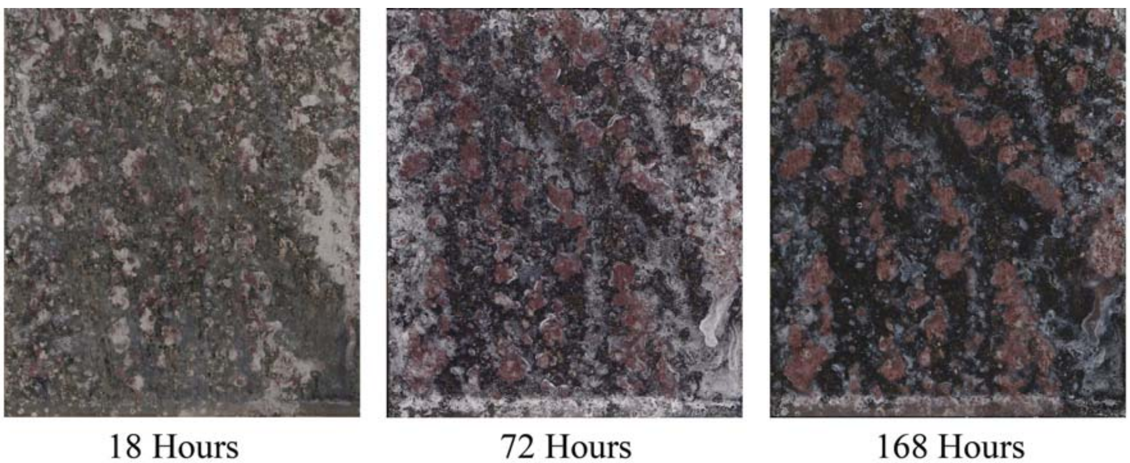


Figure 10. AA2519-T8 after NSF.

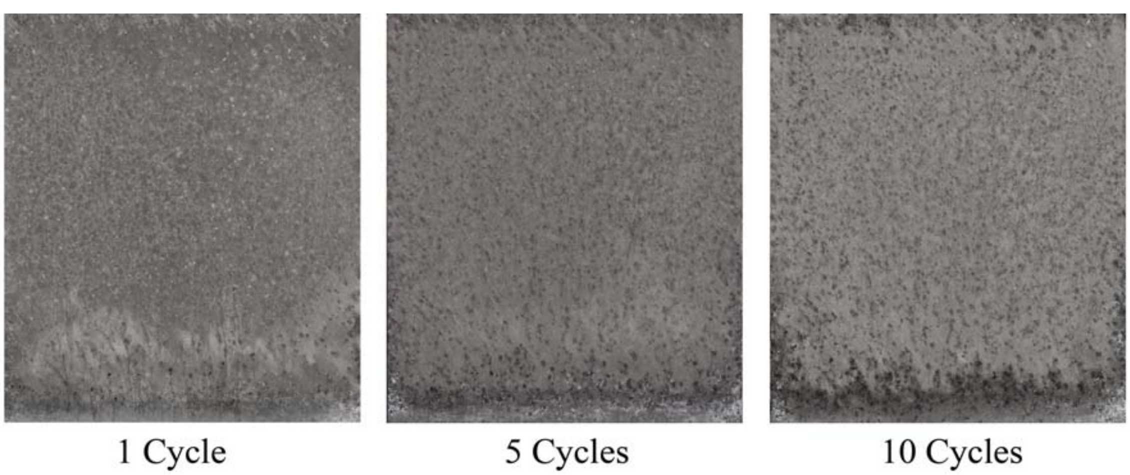


Figure 11. AA2519-T8 after GM 9540P cyclic corrosion.

Among the 2000 series alloys, the lithium (Li) alloyed AA2195 performed quite well overall when compared to the other 2000 series alloys, especially in NSF, where there was mainly staining from de-alloying of copper that was reduced on the surface with very little pitting. Additionally, aside from the staining, the NSF exposed AA2195 specimen maintained much of its smooth initial surface profile. In contrast, the other 2000 series alloys all had major surface degradation through extensive pitting and rapid formation of corrosion products. Under cyclic conditions, all of the 2000 series alloys exhibited corrosion from pitting, but the results were more inconclusive. While AA2195 had the fewest pits, they were the largest by far. The AA2024 had uniform widespread pitting nucleation. However, the size of the pits was the smallest and remained that way throughout exposure. The AA2519 exhibited the most severe pitting corrosion for NSF and GM 9540P.

3.2 5000 Series Alloys

The 5000 series aluminum-magnesium alloys are best known for their inherent corrosion resistance and form the basis for many marine grade aluminum alloys used for ship-building applications. These alloys are also extensively used for armor plating due to their good weldability and accompanying ease of fabrication for structures. Ground systems such as the M113 armored personnel carrier have withstood the test of time with respect to corrosion through their use of 5000 series aluminums. The M113 platform has operated for well over 40 years by using the AA5083 plate to form its hull. This inherent corrosion resistance is mainly imparted from the major alloying element magnesium (Mg). It should be noted that under certain circumstances, the Mg can also be the downfall for this class of alloys due to intergranular-based corrosion resulting from migration of the Mg to the grain boundaries under extended, elevated operating temperatures. This process known as sensitization becomes more pronounced as the content of any of the three factors—temperature, time at temperature, and Mg—is increased.

Due to the wide variety of ground and naval applications, a correspondingly wide variety of alloys and tempers for the same alloys was examined. In general, all of the 5000 series specimens exposed were easily among the highest in corrosion resistance for all alloys examined. However, subtle differences among the alloys and tempers in this group were revealed. The images in figures 12–31 show the relative corrosion severities sustained on the 5000 series alloys during the course of their exposures.

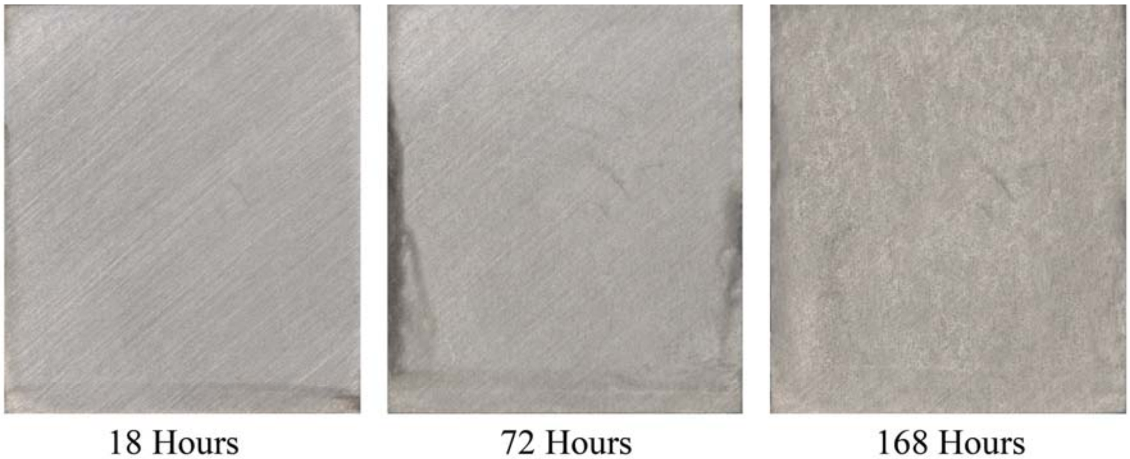


Figure 12. AA5059-H131 after NSF.

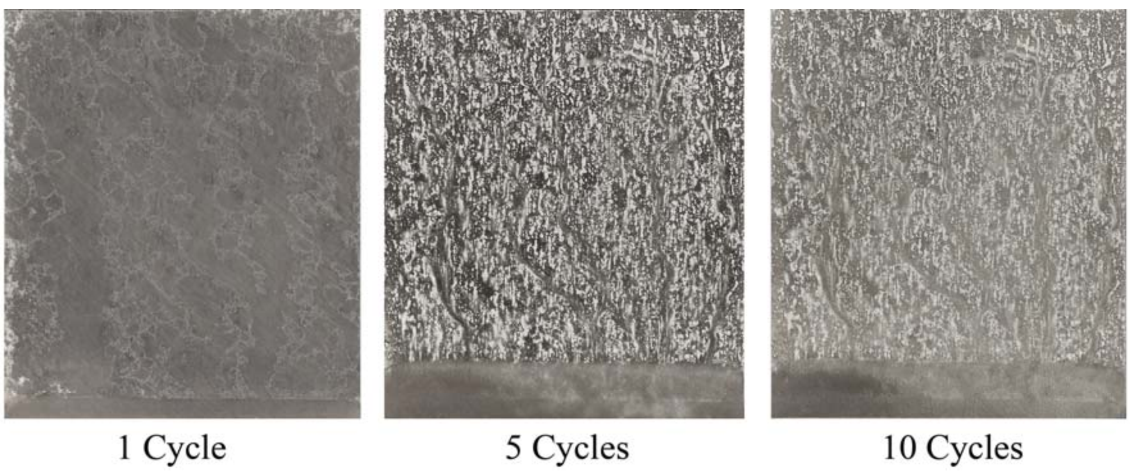
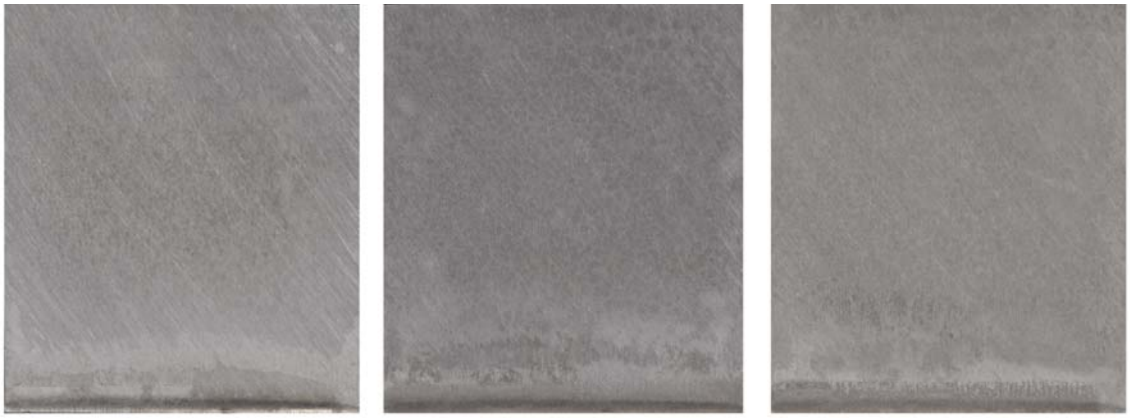


Figure 13. AA5059-H131 after GM 9540P cyclic corrosion.

Figure 14. AA5059-H321 after NSF.



1 Cycle | 5 Cycles | 10 Cycles

Figure 15. AA5059-H321 after GM 9540P cyclic corrosion.

18 Hours | 72 Hours | 168 Hours

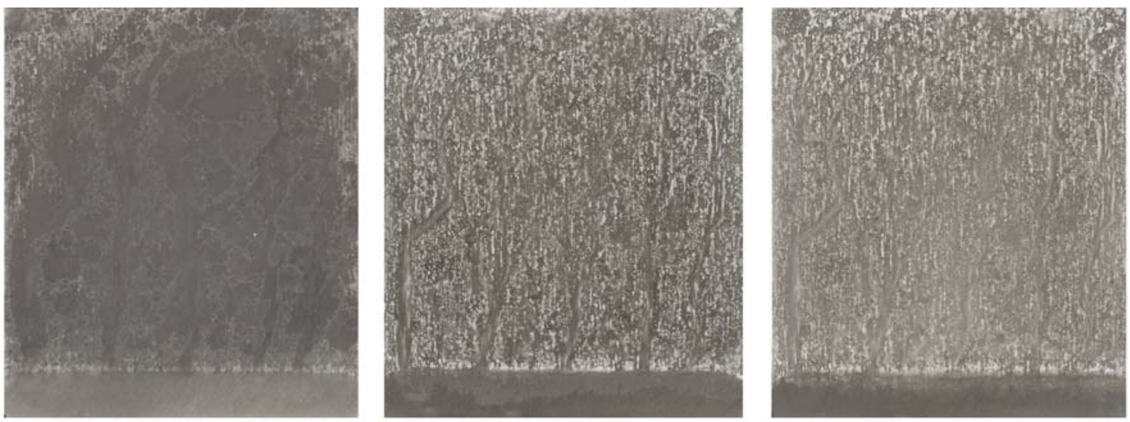
Figure 16. AA5083-H116 after NSF.

1 Cycle | 5 Cycles | 10 Cycles

Figure 17. AA5083-H116 after GM 9540P cyclic corrosion.

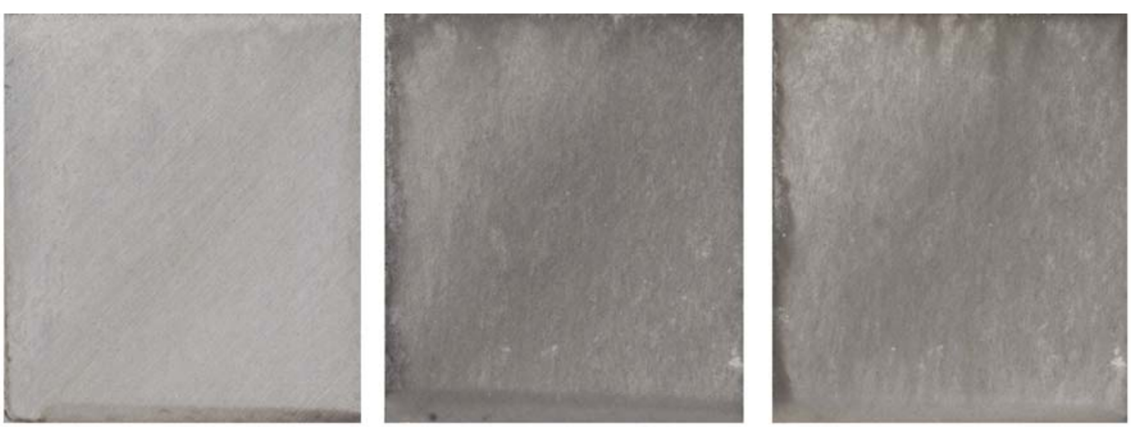
18 Hours | 72 Hours | 168 Hours

Figure 18. AA5083-H131 after NSF.



1 Cycle | 5 Cycles | 10 Cycles

Figure 19. AA5083-H131 after GM 9540P cyclic corrosion.



18 Hours | 72 Hours | 168 Hours

Figure 20. AA5083-H321 after NSF.

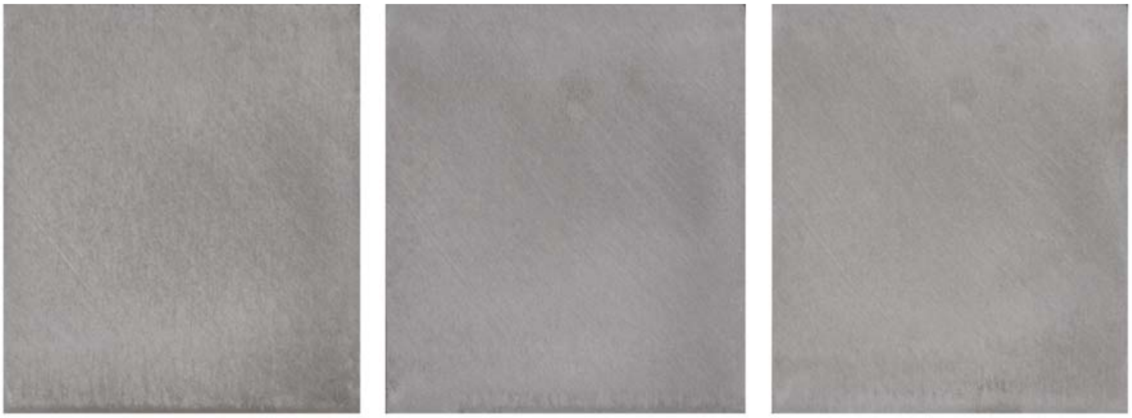


Figure 21. AA5083-H321 after GM 9540P cyclic corrosion.

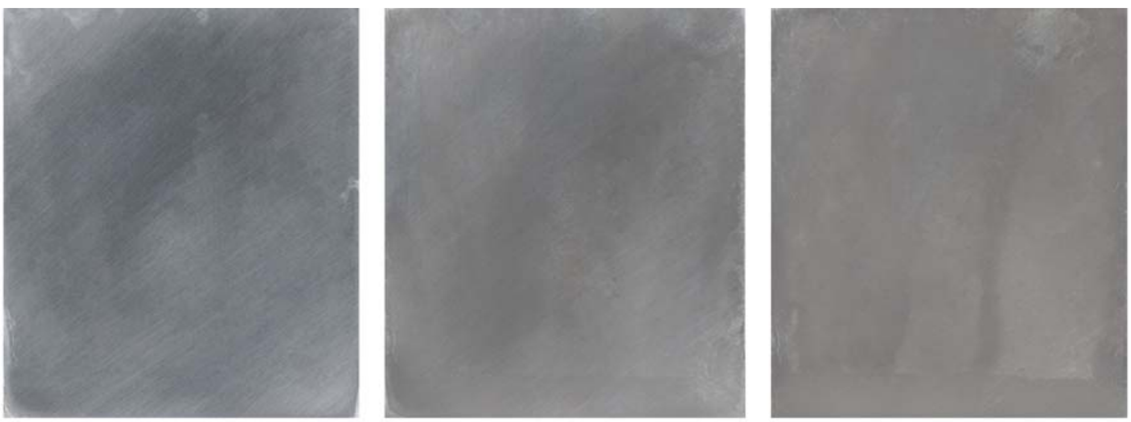


Figure 22. AA5086-H116 after NSF.

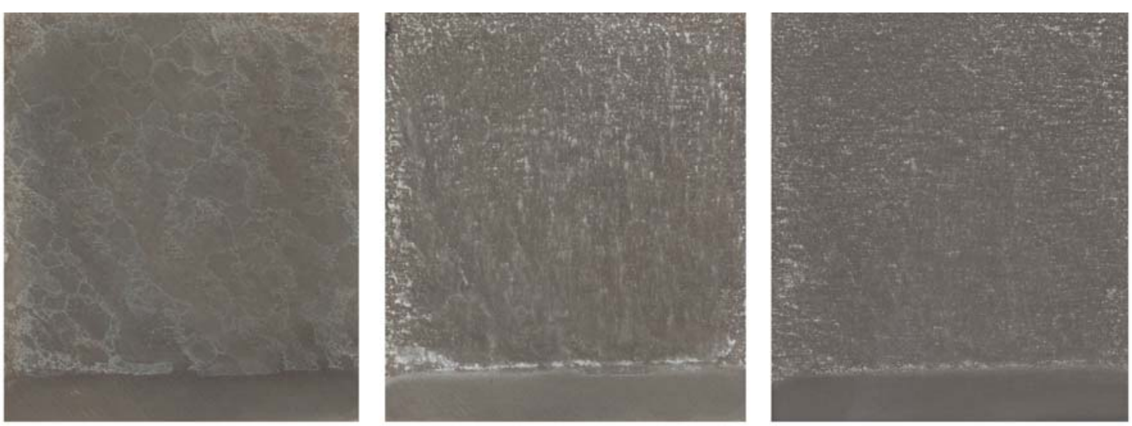


Figure 23. AA5086-H116 after GM 9540P cyclic corrosion.

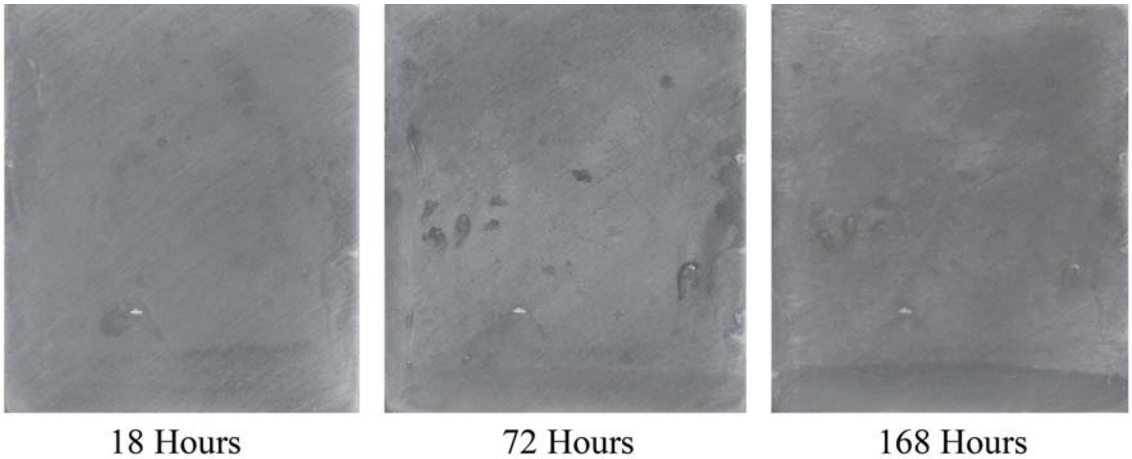


Figure 24. AA5383-H116 after NSF.

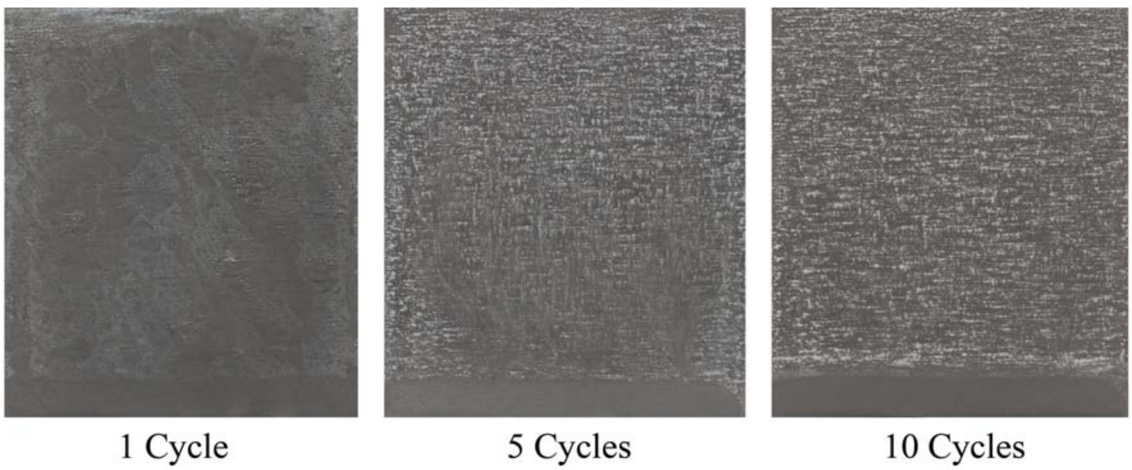


Figure 25. AA5383-H116 after GM 9540P cyclic corrosion.

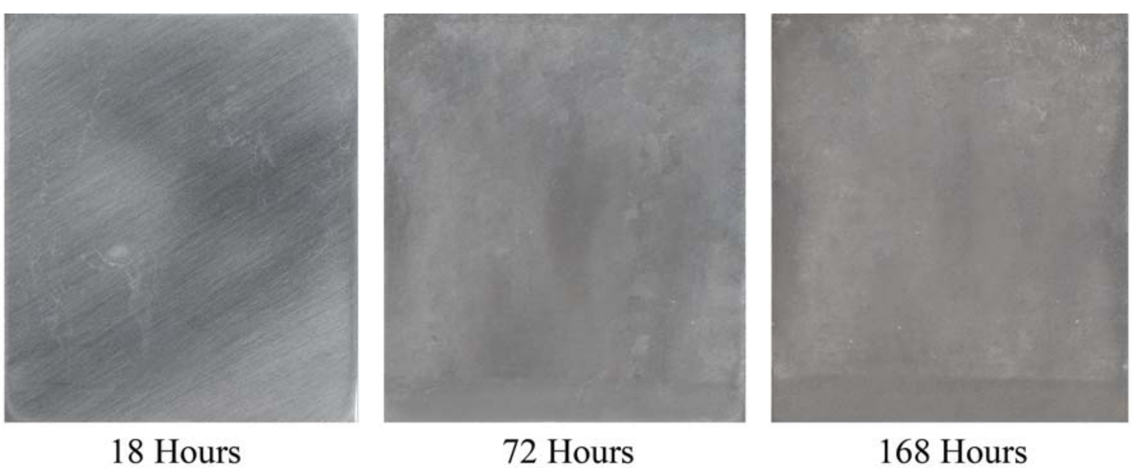
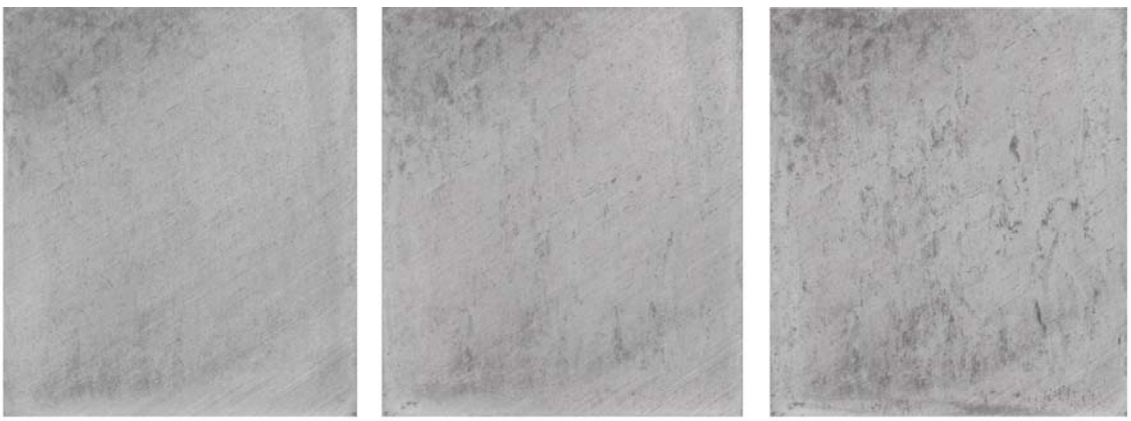


Figure 26. AA5454-H34 after NSF.

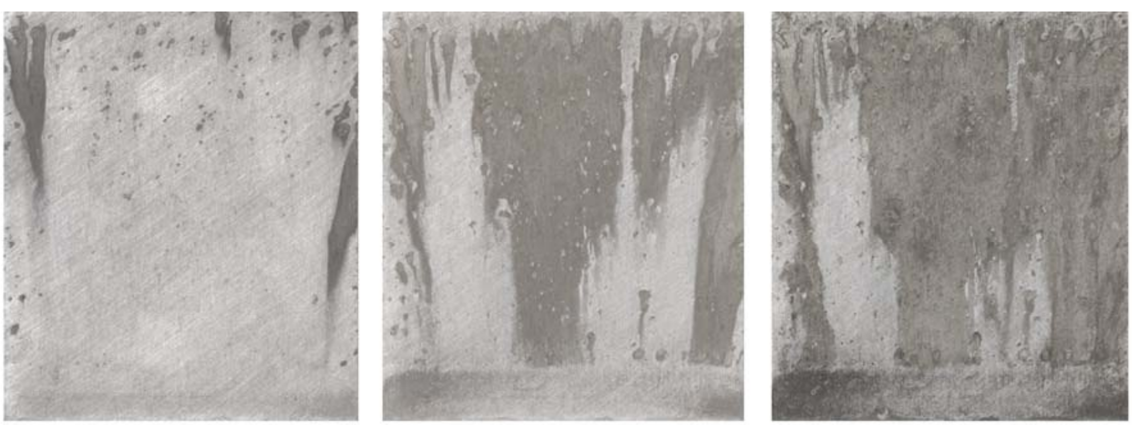
1 Cycle | 5 Cycles | 10 Cycles

Figure 27. AA5454-H34 after GM 9540P cyclic corrosion.



18 Hours | 72 Hours | 168 Hours

Figure 28. AA5456-H116 after NSF.



1 Cycle | 5 Cycles | 10 Cycles

Figure 29. AA5456-H116 after GM 9540P cyclic corrosion.

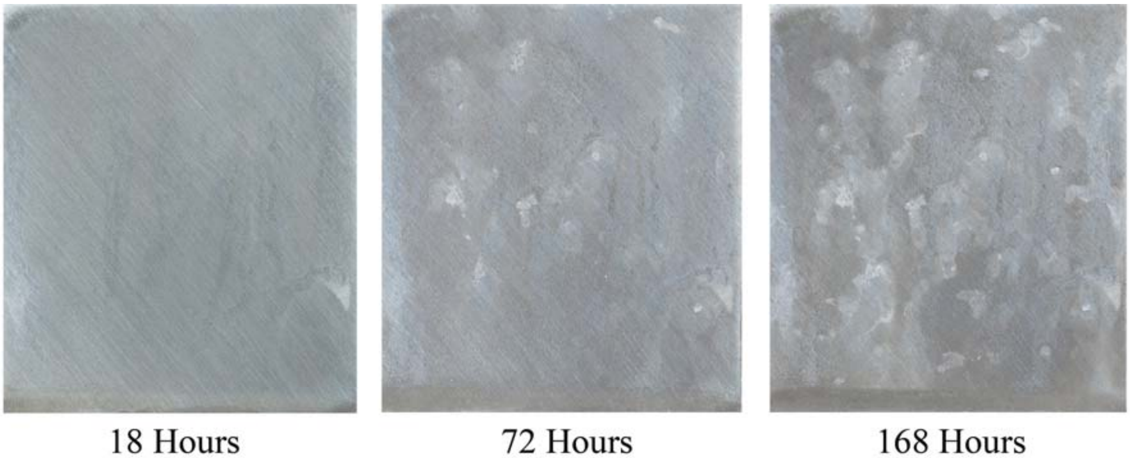


Figure 30. AA5456-H131 after NSF.

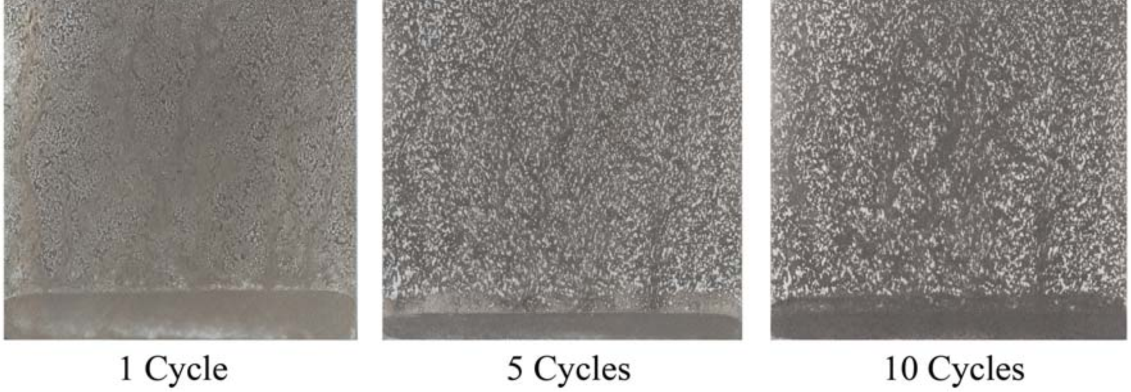


Figure 31. AA5456-H131 after GM 9540P cyclic corrosion.

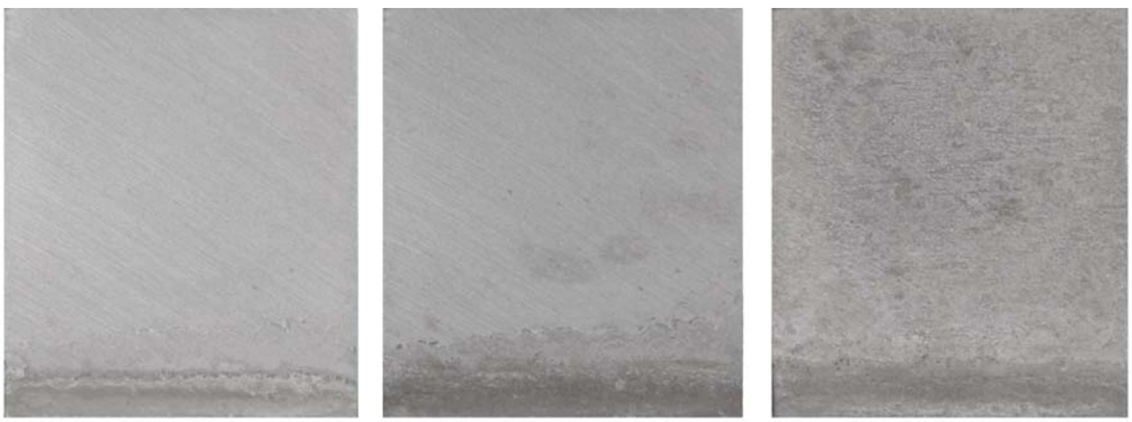
The greatest degree of pitting, though minor with only a few scattered pits, was seen on AA5456 for the H116 and H131 tempers under NSF exposure. For GM 9540P, there was mottled staining and etching that revealed the grain structure on the H131 tempers of AA5059, AA5083, and AA5456. The GM 9540P exposed AA5383-H116 also displayed the etched morphology. It should be noted that the degree of grain-based etching was most prominent among the higher Mg content H131 alloys such as AA5059 and AA5456. The H116 and H321 marine tempers for all alloys remained least affected for NSF and GM 9540P cyclic corrosion. The AA5454-H34 remained unaffected for NSF and assumed a darkened hue under GM 9540P.

3.3 6000 Series Alloys

The 6000 series are collectively known for having very good general corrosion resistance. The widely used AA6061-T651 was recently added as a military specification MIL-DTL-32262 (*4*) for appliqué armor and will find increased adoption in armored systems. Scans of the specimens depicted in figures 32–35 show the relative corrosion severities sustained for the 6000 series alloys during the course of their exposures.

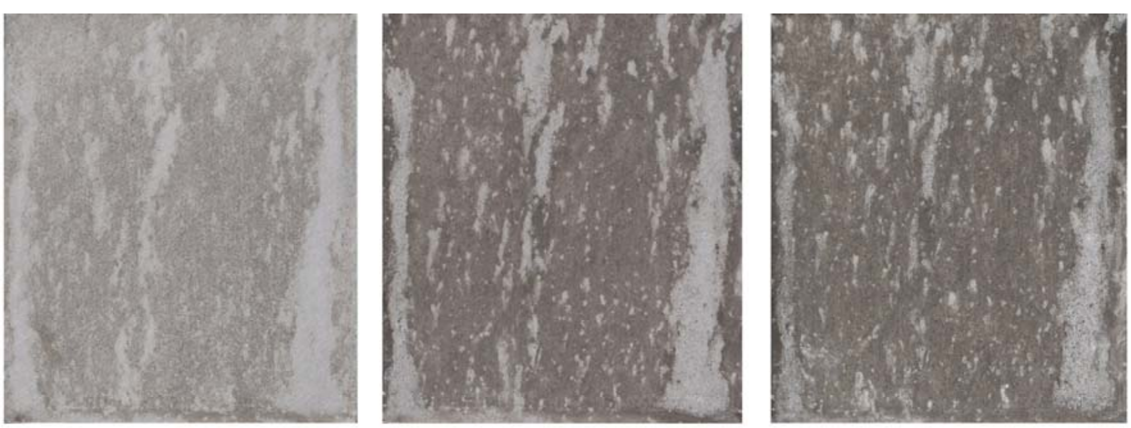
18 Hours 72 Hours 168 Hours

Figure 32. AA6013-T651 after NSF.



1 Cycle 5 Cycles 10 Cycles

Figure 33. AA6013-T651 after GM 9540P cyclic corrosion.



18 Hours 72 Hours 168 Hours

Figure 34. AA6061-T651 after NSF.

Figure 35. AA6061-T651 after GM 9540P cyclic corrosion.

When evaluated for general corrosion under each of the accelerated environments, the AA6061 performed well, with only minor discolorations under GM 9540P and minor pitting and stains under NSF. A higher strength 6000 series alloy studied for ballistic applications, AA6013-T651, exhibited greater corrosion than expected for a typical 6000 series alloy. It sustained significant pitting damage under NSF conditions appearing at just 18 h as well as minor staining and pits that became visible after 10 cycles of GM 9540P, whereas the AA6061 was essentially undamaged for corresponding exposures.

3.4 7000 Series Alloys

Similar to 2000 series aluminums, the 7000 series aluminums are widely used in DOD for their high strength and stiffness in aviation and missiles and their good performance as ballistic armor plates. As with 2024-T3, the alloy 7075-T6 has been a long time staple among Navy and Air Force aircraft, again, for its high-end mechanical properties. The alloy AA7039-T64 is the basis for the Military Specification MIL-DTL-46063H (*5*) used in armor plate and has been used in ground systems such as the M2 bradley fighting vehicle. The 7000 series aluminums are most widely known for corrosion damage due to stress corrosion cracking, particularly in aviation where a sudden failure can produce a catastrophic result. The 7000 series alloys studied exhibited a wide range of general corrosion damage. The images in figures 36–41 show the relative corrosion severities sustained on the 7000 series alloys for their respective exposures.

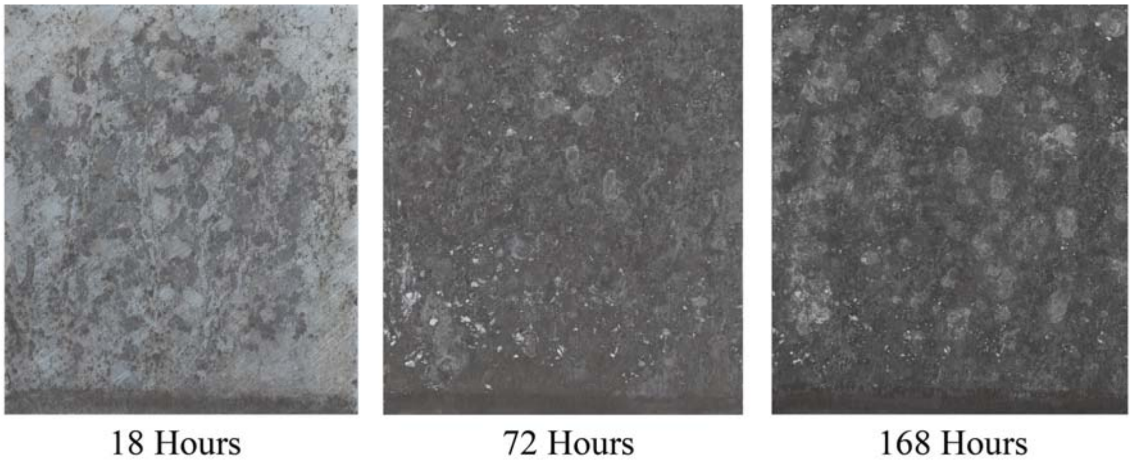


Figure 36. AA7022-T651 after NSF.

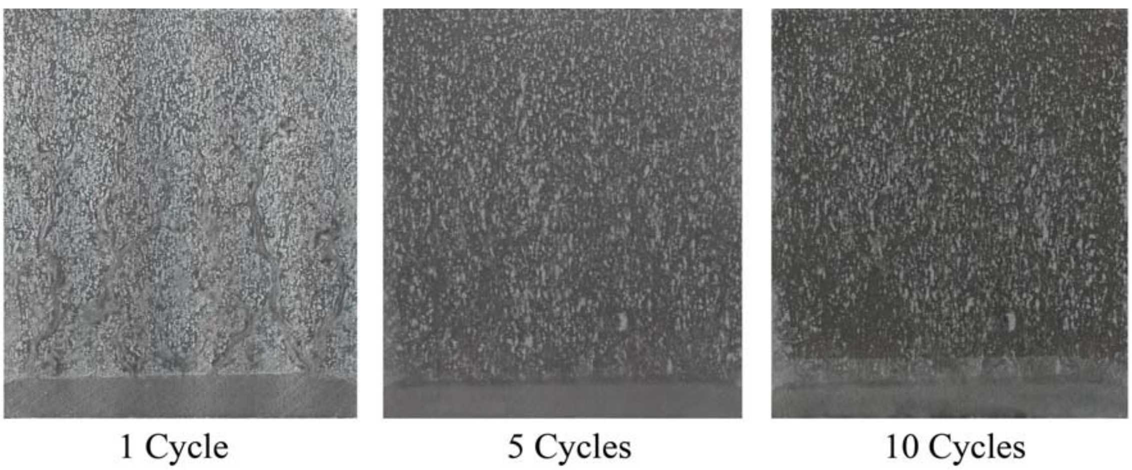


Figure 37. AA7022-T651 after GM 9540P cyclic corrosion.

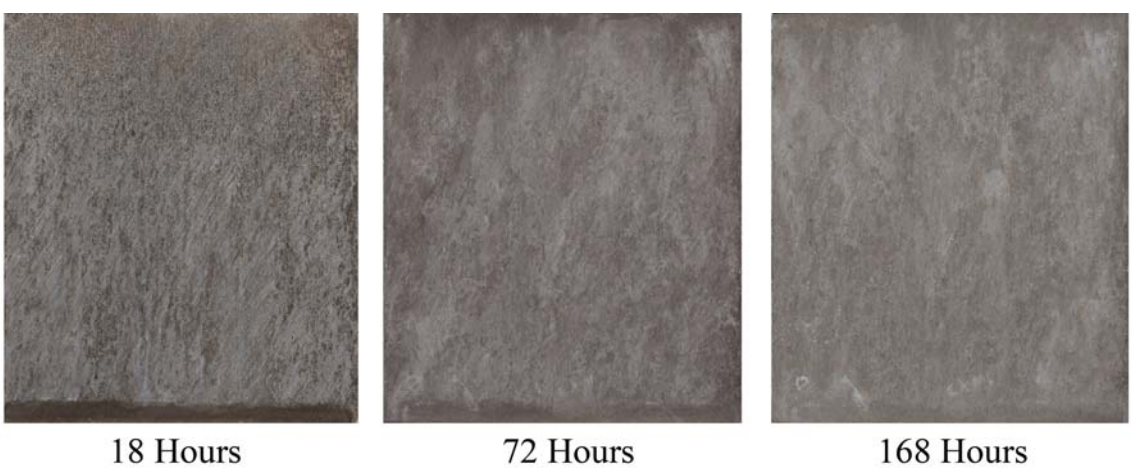


Figure 38. AA7039-T64 after NSF.

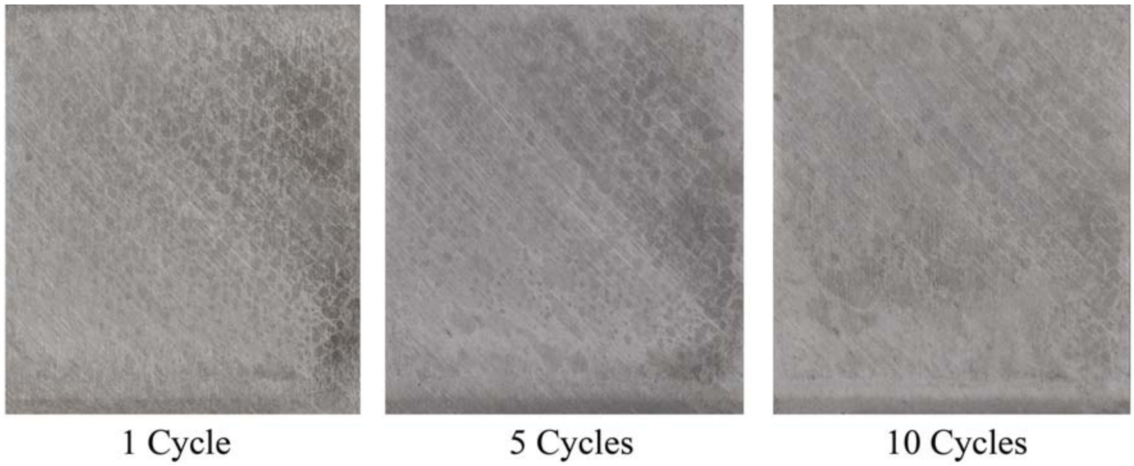


Figure 39. AA7039-T64 after GM 9540P cyclic corrosion.

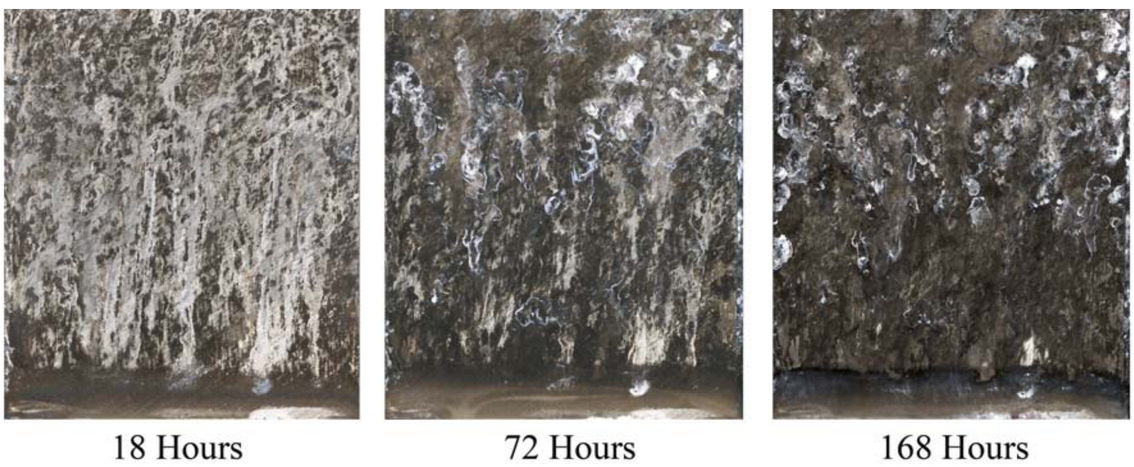


Figure 40. AA7075-T651 after NSF.

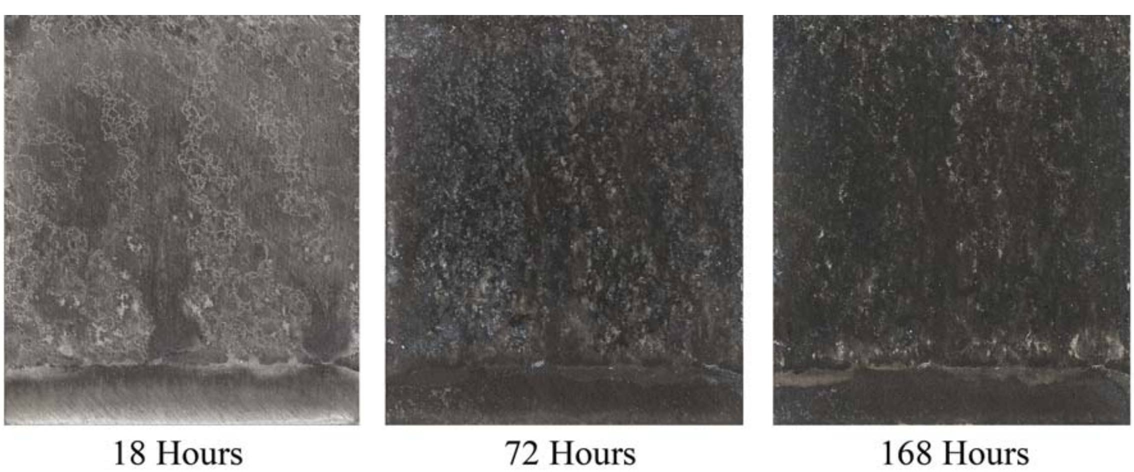


Figure 41. AA7075-T651 after GM 9540P cyclic corrosion.

While there was some minor pitting attack and dark oxidation stains for AA7075 and AA7022, the corrosion observed for 7000 series aluminums was less severe overall than observed for the 2000 series alloys. The pits that did nucleate produced white corrosion products with no significant copper depositions from de-alloying. In bold contrast with the other 7000 series alloys studied, the AA7039-T64 armor alloy showed very little corrosion damage vs. the others from the 7000 series. Overall, the general corrosion resistance of the 7039 observed was actually among the best for all of the alloys studied, even including the 5000 series alloys. In particular, under GM 9540P, the AA7039 corrosion resistance was outstanding and cosmetically resembled a marine-grade 5000 series alloy. The extent of pitting and staining for AA7039 under NSF conditions was relatively minor, even after the full 168-h duration.

4. Discussion

The alloys evaluated generally performed as expected when compared with each other series vs. series under accelerated corrosion, with 5000 series being the most corrosion resistant and 2000 series being the least corrosion resistant. Some interesting exceptions were obviously found for each category and should not be overlooked. The AA2195-BT proposed for armor fared significantly better in accelerated corrosion resistance vs. the other 2000 alloys, especially in wet conditions, while simultaneously being stronger. Its biggest drawback was cost and weldability due to its Li additions. For the 7000 series aluminums, the biggest drawback has historically been from susceptibility to stress corrosion cracking. More recently developed 7000 series aluminums such as 7022 attempt to address this issue. While the 5000 series aluminums were the most corrosion resistant under accelerated corrosion conditions, caution is nevertheless required when potentially selecting these alloys as sensitization remains a potential issue (*23*). As with inherent corrosion weaknesses in other types of aluminum alloys, the sensitization vulnerability of the 5000 series alloys can be minimized when proper considerations are made regarding the alloy’s intended use, its magnesium content, and the sustained temperatures of its operating environment. The large sampling of 5000 series alloys precluded their presence within this study in a sensitized condition. Additional images obtained of AA5456-H131 samples sensitized for 4 days at 125 °C and exposed (figure 42) under NSF have revealed that the impact on corrosion due to sensitization, even just for pitting corrosion, can be profound. Thus, further studies are underway for 5000 series alloys under sensitized conditions.

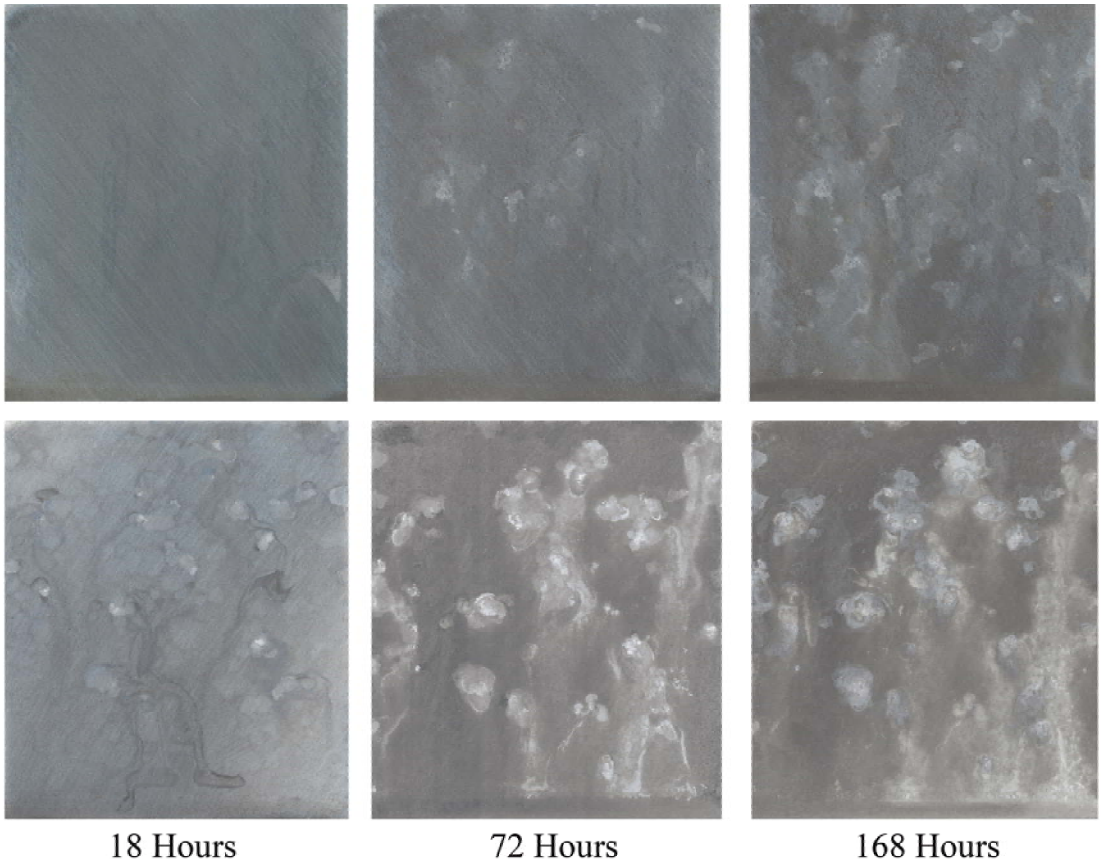


Figure 42. As-received 5456-H131 (top row) vs. 5456-H131 sensitized for 4 days at 125 °C under NSF (bottom row).

Except for more mundane tasks such as heat sink applications for cooling of electronics, extrusions for trailers, support equipment, and other lightweight structures, the 6000 series alloys have been the least used in DOD for actual weapon systems. The recent inclusion of AA6061-T651 as an appliqué armor specification has already increased its presence due to positive factors beyond ballistic performance such as low cost, high abundance, and relatively good corrosion resistance (*24*).

The intent of this study was to provide a convenient reference or guide to high-performance aluminum alloys currently in use or likely suitable for DOD applications. The chamber-based accelerated corrosion methods employed originated as quick screening methods to estimate the likelihood of whether or not a particular aluminum alloy of interest would experience general corrosion issues. By exposing a wide variety of alloys including those currently in use, a relative comparison and qualitative ranking becomes feasible. Many military and civilian aluminum-based systems have historically been designed by default through the selection of the strongest alloy available. While designing a system or a component to be much stronger than its expected load for safety and extended life is always commendable, the best intentions do not always produce the best results.

Of the two laboratory-accelerated corrosion methods employed, the NSF produced greater corrosion impact across the spectrum of alloys studied. For GM 9540P, the corrosion damage was, in the majority, less severe, with only the 2000 and 7000 series showing more significant damage. As previously stressed, these accelerated corrosion conditions were used to screen these alloys and cannot/should not form the basis for an accurate lifecycle prediction when used in an actual system. They can provide reasonable expectations for corrosion that, when accompanied by minimum mechanical property acceptance values, can help system designers select the best (not necessarily the strongest) aluminum alloy for their specific application. Furthermore, these comparisons can help select applicable coatings systems and/or surface pretreatments based upon service requirements to impart the best performance and durability for a specific mission. The addition of corrosion resistance as a selection criteria can potentially offset other factors such as initial material cost and/or subsequent total cost of ownership by avoiding costly repairs from corrosion.

5. Conclusions

1. Of the two laboratory accelerated corrosion methods used, ASTM B 117 NSF was more severe across all of the alloys when compared to GM 9540P.
2. There was agreement between the two laboratory methods, with the least corrosion resistant aluminum samples for one procedure being the least resistant for the other.
3. The 2000 and 7000 series alloys had the worst corrosion resistance.
4. The 5000 and 6000 series alloys were most corrosion resistant.
5. Chamber-based accelerated corrosion was a rapid and useful screening tool to compare aluminum alloys but should not be used for lifecycle prediction.

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